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Oil Containment¹

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Containment and control of oil spills at electric supply substations is a concern for most electric utilities. The environmental impact of oil spills and their cleanup is governed by several federal, state, and local regulations, necessitating increased attention in substations to the need for secondary oil containment, and a Spill Prevention Control and Countermeasure (SPCC) plan. Beyond the threat to the environment, cleanup costs associated with oil spills could be significant, and the adverse community response to any spill is becoming increasingly unacceptable.

The probability of an oil spill occurring in a substation is very low. However, certain substations, due to their proximity to navigable waters or designated wetlands, the quantity of oil on site, surrounding topography, soil characteristics, etc., have or will have a higher potential for discharging harmful quantities of oil into the environment. At minimum, an SPCC plan will probably be required at these locations, and installation of secondary oil-containment facilities might be the right approach to mitigate the problem.

Before an adequate spill prevention plan is prepared and a containment system is devised, the engineer must first be thoroughly aware of the requirements included in the federal, state, and local regulations.

The federal requirements of the U.S. for discharge, control, and countermeasure plans for oil spills are contained in the Code of Federal Regulations, Title 40 (40CFR), Parts 110 and 112. The above regulations only apply if the facility meets the following conditions:

1. Facilities with above-ground storage capacities greater than 2500 l (approximately 660 gal) in a single container or 5000 l (approximately 1320 gal) in aggregate storage, *or*
2. Facilities with a total storage capacity greater than 159,000 l (approximately 42,000 gal) of buried oil storage, *or*

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3. Any facility which has spilled more than 3786 l (1000 gal) of oil in a single event or spilled oil in two events occurring within a 12-month period, and
4. Facilities which, due to their location, could reasonably be expected to discharge oil into or upon the navigable waters of the U.S. or its adjoining shorelines.

In other countries, applicable governmental regulations will cover the above requirements.

8.1 Oil-Filled Equipment in Substation [IEEE 980-1994 (R2001)]

A number of electrical apparatus installed in substations are filled with oil that provides the necessary insulation characteristics and assures their required performance. Electrical faults in this power equipment can produce arcing and excessive temperatures that may vaporize insulating oil, creating excessive pressure that may rupture the electrical equipment tanks. In addition, operator errors, sabotage, or faulty equipment may also be responsible for oil releases.

The initial cause of an oil release or fire in electrical apparatus may not always be avoidable, but the extent of damage and the consequences for such an incident can be minimized or prevented by adequate planning in prevention and control.

Described below are various sources of oil spills within substations. Spills from any of these devices are possible. The user must evaluate the quantity of oil present, the potential impact of a spill, and the need for oil containment associated with each oil-filled device.

8.1.1 Large Oil-Filled Equipment

Power transformers, oil-filled reactors, large regulators, and circuit breakers are the greatest potential source of major oil spills in substations, since they typically contain the largest quantity of oil.

Power transformers, reactors, and regulators may contain anywhere from a few hundred to 100,000 l or more of oil (500 to approximately 30,000 gal), with 7500–38,000 l (approximately 2000–10,000 gal) being typical. Substations usually contain one to four power transformers, but may have more.

The higher voltage oil circuit breakers may have three independent tanks, each containing 400–15,000 l (approximately 100–4000 gal) of oil, depending on their rating. However, most circuit breaker tanks contain less than 4500 l (approximately 1200 gal) of oil. Substations may have 10–20 or more oil circuit breakers.

8.1.2 Cables

Substation pumping facilities and cable terminations (potheads) that maintain oil pressure in pipe-type cable installations are another source of oil spills. Depending on its length and rating, a pipe-type cable system may contain anywhere from 5000 l (approximately 1500 gal) up to 38,000 l (approximately 10,000 gal) or more of oil.

8.1.3 Mobile Equipment

Although mobile equipment and emergency facilities may be used infrequently, consideration should be given to the quantity of oil contained and associated risk of oil spill. Mobile equipment may contain up to 30,000 l (approximately 7500 gal) of oil.

8.1.4 Oil-Handling Equipment

Oil filling of transformers, circuit breakers, cables, etc. occurs when the equipment is initially installed. In addition, periodic reprocessing or replacement of the oil may be necessary to ensure that proper insulation qualities are maintained. Oil pumps, temporary storage facilities, hoses, etc. are brought in to accomplish this task. Although oil processing and handling activities are less common, spills from these devices can still occur.

8.1.5 Oil Storage Tanks

Some consideration must be given to the presence of bulk oil storage tanks (either above-ground or below-ground) in substations as these oil tanks could be responsible for an oil spill of significant magnitude. Also, the resulting applicability of the 40CFR, Part 112 rules for these storage tanks could require increased secondary oil containment for the entire substation facility. The user may want to reconsider storage of bulk oil at substation sites.

8.1.6 Other Sources

Station service, voltage, and current transformers, as well as smaller voltage regulators, oil circuit reclosers, capacitor banks, and other pieces of electrical equipment typically found in substations, contain small amounts of insulating oil, usually less than the 2500 l (approximately 660 gal) minimum for a single container.

8.2 Spill Risk Assessment

The risk of an oil spill caused by an electric equipment failure is dependent on many factors, including:

- Engineering and operating practices (i.e., electrical fault protection, loading practices, switching operations, testing, and maintenance).
- Quantities of oil contained within apparatus.
- Station layout (i.e., spatial arrangement, proximity to property lines, streams, and other bodies of water).
- Station topography and site preparation (i.e., slope, soil conditions, ground cover).
- Rate of flow of discharged oil.

Each facility must be evaluated to select the safeguards commensurate with the risk of a potential oil spill.

The engineer must first consider whether the quantities of oil contained in the station exceed the quantities of oil specified in the Regulations, and secondly, the likelihood of the oil reaching navigable waters if an oil spill or rupture occurs. If no likelihood exists, no SPCC plan is required.

SPCC plans must be prepared for each piece of portable equipment and mobile substations. These plans have to be general enough that the plan may be used at any and all substations or facility location.

Both the frequency and magnitude of oil spills in substations can be considered to be very low. The probability of an oil spill at any particular location depends on the number and volume of oil containers, and other site-specific conditions.

Based on the applicability of the latest regulatory requirements, or when an unacceptable level of oil spills has been experienced, it is recommended that a program be put in place to mitigate the problems. Typical criteria for implementing oil spill containment and control programs incorporate regulatory requirements, corporate policy, frequency and duration of occurrences, cost of occurrences, safety hazards, severity of damage, equipment type, potential impact on nearby customers, substation location, and quality-of-service requirements [IEEE 980-1994 (R2001)].

The decision to install secondary containment at new substations (or to retrofit existing substations) is usually based on predetermined criteria. A 1992 IEEE survey addressed the factors used to determine where oil spill containment and control programs are needed. Based on the survey, the criteria in [Table 8.1](#) are considered when evaluating the need for secondary oil containment.

The same 1992 IEEE survey provided no clear-cut limit for the proximity to navigable waters. Relatively, equal support was reported for several choices over the range of 45–450 m (150–1500 feet).

Rarely is all of the equipment within a given substation provided with secondary containment. [Table 8.2](#) lists the 1992 IEEE survey results identifying the equipment for which secondary oil containment is provided.

TABLE 8.1 Secondary Oil-Containment Evaluation Criteria

Criteria	Utilities Responding That Apply This Criteria
Volume of oil in individual device	88%
Proximity to navigable waters	86%
Total volume of oil in substation	62%
Potential contamination of groundwater	61%
Soil characteristics of the station	42%
Location of substation (urban, rural, remote)	39%
Emergency response time if a spill occurs	30%
Failure probability of the equipment	21%
Age of station or equipment	10%

Source: IEEE 980-1994 (R2001).

TABLE 8.2 Secondary Oil-Containment Equipment Criteria

Equipment	Utilities Responding That Provide Secondary Containment
Power transformers	86%
Above-ground oil storage tanks	77%
Station service transformers	44%
Oil circuit breakers	43%
Three-phase regulators	34%
Below-ground oil storage tanks	28%
Shunt reactors	26%
Oil-filling equipment	22%
Oil-filled cables and terminal stations	22%
Single-phase regulators	19%
Oil circuit reclosers	15%

Source: IEEE 980-1994 (R2001).

Whatever the criteria, each substation has to be evaluated by considering the criteria to determine candidate substations for oil-containment systems (both new and retrofit). Substations with planned equipment change-outs and located in environmentally sensitive areas have to be considered for retrofits at the time of the change-out.

8.3 Containment Selection Consideration [IEEE 980-1994 (R2001)]

Containment selection criteria have to be applied in the process of deciding the containment option to install in a given substation. Criteria to be considered include: operating history of the equipment, environmental sensitivity of the area, the solution's cost-benefit ratio, applicable governmental regulations, and community acceptance.

The anticipated cost of implementing the containment measures must be compared to the anticipated benefit. However, cost alone can no longer be considered a valid reason for not implementing containment and/or control measures, because any contamination of navigable waters may be prohibited by government regulations.

Economic aspects can be considered when determining which containment system or control method to employ. Factors such as proximity to waterways, volume of oil, response time following a spill, etc., can allow for the use of less effective methods at some locations.

Due to the dynamic nature of environmental regulations, some methods described in this section of the handbook could come in conflict with governmental regulations or overlapping jurisdictions. Therefore,

TABLE 8.3 Soil Permeability Characteristics

Permeability (cm/sec)	Degree of Permeability	Type of Soil
Over 10^{-1}	High	Stone, gravel, and coarse- to medium-grained sand
10^{-1} to 10^{-3}	Medium	Medium-grained sand to uniform, fine-grained sand
10^{-3} to 10^{-6}	Low	Uniform, fine-grained sand to silty sand or sandy clay
Less than 10^{-6}	Practically impermeable	Silty sand or sandy clay to clay

Source: IEEE 980-1994 (R2001).

determination of which containment system or control method to use must include research into applicable laws and regulations.

Community acceptance of the oil spill containment and control methods is also to be considered. Company policies, community acceptance, customer relations, etc. may dictate certain considerations. The impact on adjacent property owners must be addressed and, if needed, a demonstration of performance experiences could be made available.

8.4 Oil Spill Prevention Techniques

Upon an engineering determination that an oil spill prevention system is needed, the engineer must weigh the advantages and disadvantages that each oil retention system may have at the facility in question. The oil retention system chosen must balance the cost and sophistication of the system to the risk of the damage to the surrounding environment. The risks, and thus the safeguards, will depend on items such as soil, terrain, relative closeness to waterways, and potential size of discharge. Each of the systems that are described below may be considered based on their relative merits to the facility under consideration. Thus, one system will not always be the best choice for all situations and circumstances.

8.4.1 Containment Systems

The utility has to weigh the advantages and disadvantages that each oil retention system may have at the facility in question. Some of the systems that could be considered based on their relative merits to the facility under consideration are presented in the next paragraphs.

8.4.1.1 Yard Surfacing and Underlying Soil

100 to 150 mm (4 to 6 in.) of rock gravel surfacing are normally required in all electrical facility yards. This design feature benefits the operation and maintenance of the facility by providing proper site drainage, reducing step and touch potentials during short-circuit faults, eliminating weed growth, improving yard working conditions, and enhancing station aesthetics. In addition to these advantages, this gravel will aid in fire control and in reducing potential oil spill cleanup costs and penalties that may arise from federal and state environmental laws and regulations.

Yard surfacing is not to be designed to be the primary or only method of oil containment within the substation, but rather has to be considered as a backup or bonus in limiting the flow of oil in the event that the primary system does not function as anticipated.

Soil underlying power facilities usually consists of a nonhomogeneous mass that varies in composition, porosity, and physical properties with depth.

Soils and their permeability characteristics have been adapted from typical references and can be generalized as in the following Table 8.3.

8.4.1.2 Substation Ditching

One of the simplest methods of providing total substation oil spill control is the construction of a ditch entirely around the outside periphery of the station. The ditch has to be of adequate size as to contain

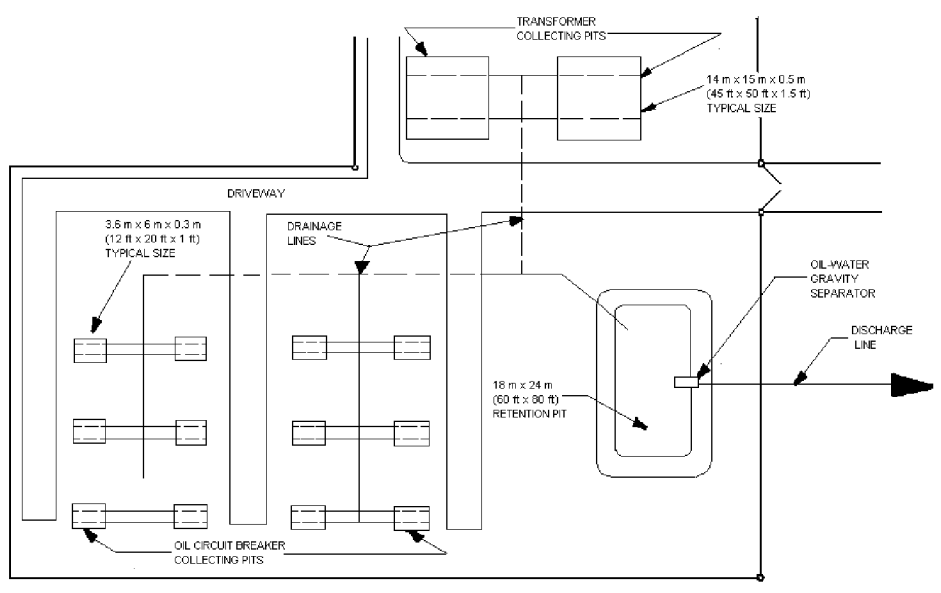


FIGURE 8.3 Typical containment system with retention and collection pits.

all surface run-offs due to rain and insulating oil. These ditches may be periodically drained by the use of valves.

8.4.1.3 Collecting Ponds with Traps

In this system, the complete design consists of a *collection pit* surrounding the protected equipment, drains connecting the collection pits to an open *containment pit*, and an oil trap which is sometimes referred to as a skimming unit and the discharge drain. Figure 8.1 [IEEE 980-1994 (R2001)] presents the general concept of such a containment solution. The collection pit surrounding the equipment is filled with rocks and designed only deep enough to extinguish burning oil. The bottom of this pit is sloped for good drainage to the drainpipe leading to an open containment pit. This latter pit is sized to handle all the oil of the largest piece of equipment in the station. To maintain a dry system in the collecting units, the invert of the intake pipe to the containment pit must be at least the maximum elevation of the oil level. In areas of the country subject to freezing temperatures, it is recommended that the trap (skimmer) be encased in concrete, or other similar means available, to eliminate heaving due to ice action.

8.4.1.4 Oil Containment Equipment Pits

Probably one of the most reliable but most expensive methods of preventing oil spills and insuring that oil will be contained on the substation property is by placing all major substation equipment on or in containment pits. This method of oil retention provides a permanent means of oil containment. These containment pits will confine the spilled oil to relatively small areas that in most cases will greatly reduce the cleanup costs.

One of the most important issues related to an equipment pit is to prevent escape of spilled oil into underlying soil layers. Pits with liners or sealers may be used as part of an oil containment system capable of retaining any discharged oil for an extended period of time. Any containment pit must be constructed with materials having medium to high permeability (above 10^{-3} cm/sec) and be sealed in order to prevent migration of spilled oil into underlying soil layers and groundwater. These surfaces may be sealed and/or lined with any of the following materials:

1. Plastic or rubber — Plastic or rubber liners may be purchased in various thickness and sizes. It is recommended that a liner be selected that is resistant to mechanical injury which may occur due to construction and installation, equipment, chemical attacks on surrounding media, and oil products.

2. Bentonite (clay) — Clay and Bentonite may also be used to seal electrical facility yards and containment pits. These materials can be placed directly in 100 to 150 mm (4 to 6 in.) layers or may be mixed with the existing subsoil to obtain an overall soil permeability of less than 10^{-3} cm/sec.
3. Spray-on fiberglass — Spray-on fiberglass is one of the most expensive pit liners available, but in some cases, the costs may be justifiable in areas which are environmentally sensitive. This material offers very good mechanical strength properties and provides excellent oil retention.
4. Reinforced concrete — 100 to 150 mm (4 to 6 in.) of reinforced concrete may also be used as a pit liner. This material has an advantage over other types of liners in that it is readily available at the site at the time of initial construction of the facility. Concrete has some disadvantages in that initial preparation is more expensive and materials are not as easily workable as some of the other materials.

If materials other than those listed above are used for an oil containment liner, careful consideration must be given to selecting materials, which will not dissolve or become soft with prolonged contact with oil, such as asphalt.

8.4.1.4.1 Fire Quenching Considerations [IEEE 980-1994 (R2001)]

In places where the oil-filled device is installed in an open pit (not filled with stone), an eventual oil spill associated with fire will result in a pool fire around the affected piece of equipment. If a major fire occurs, the equipment will likely be destroyed. Most utilities address this concern by employing active or passive quenching systems, or drain the oil to a remote pit. Active systems include foam or water spray deluge systems.

Of the passive fire quenching measures, pits filled with crushed stone are the most effective. The stone-filled pit provides a fire quenching capability designed to extinguish flames in the event that a piece of oil-filled equipment catches on fire. An important point is that in sizing a stone-filled collecting or retention pit, the final oil level elevation (assuming a total discharge) has to be situated approximately 300 mm (12 in.) below the top elevation of the stone.

All the materials used in construction of a containment pit have to be capable of withstanding the higher temperatures associated with an oil fire without melting. If any part of the containment (i.e., discharge pipes from containment to a sump) melts, the oil will be unable to drain away from the burning equipment, and the melted materials may pose an environmental hazard.

8.4.1.4.2 Volume Requirements

Before a substation oil-containment system can be designed, the volume of oil to be contained must be known. Since the probability of an oil spill occurring at a substation is very low, the probability of simultaneous spills is extremely low. Therefore, it would be unreasonable and expensive to design a containment system to hold the sum total of all of the oil contained in the numerous oil-filled pieces of equipment normally installed in a substation. In general, it is recommended that an oil-containment system be sized to contain the volume of oil in the single largest oil-filled piece of equipment, plus any accumulated water from sources such as rainwater, melted snow, and water spray discharge from fire protection systems. Interconnection of two or more pits to share the discharged oil volume may provide an opportunity to reduce the size requirements for each individual pit.

Typically, equipment containment pits are designed to extend 1.5–3 m (5–10 ft) beyond the edge of the tank in order to capture a majority of the leaking oil. A larger pit size is required to capture all of the oil contained in an arcing stream from a small puncture at the bottom of the tank (such as from a bullet hole). However, the low probability of the event and economic considerations govern the 1.5–3 m (5–10 ft) design criteria. For all of the oil to be contained, the pit or berm has to extend 7.5 m (25 ft) or more beyond the tank and radiators.

The volume of the pit surrounding each piece of equipment has to be sufficient to contain the spilled oil in the air voids between the aggregate of gravel fill or stone. A gravel gradation with a nominal size of 19–50 mm (3/4 to 2 in.) which results in a void volume between 30 and 40% of the pit volume is generally being used. The theoretical maximum amount of oil that can be contained in 1 ft³ or 1 m³ of stone is given by the following formulae:

$$\text{Oil Volume [gal]} = \frac{\text{void volume of stone [\%]}}{100 \times 0.1337 \text{ ft}^3} \quad (8.1)$$

$$\text{Oil Volume [l]} = \frac{\text{void volume of stones [\%]}}{100 \times 0.001 \text{ m}^3} \quad (8.2)$$

where 1 gallon = 0.1337 ft³ and 1 liter = 0.001 m³ = 1 dm³.

If the pits are not to be automatically drained of rainwater, then an additional allowance must be made for precipitation. The additional space required would depend on the precipitation for that area and the frequency at which the facility is periodically inspected. It is generally recommended that the pits have sufficient space to contain the amount of rainfall for this period plus a 20% safety margin.

Expected rain and snow accumulations can be determined from local weather records. A severe rainstorm is often considered to be the worst-case event when determining the maximum volume of short-term water accumulation (for design purposes). From data reported in a 1992 IEEE survey, the storm water event design criteria employed ranged from 50 to 200 mm (2 to 8 in.) of rainfall within a short period of time (1–24 h). Generally accepted design criteria is assuming a 1 in 25-year storm event.

The area directly surrounding the pit must be graded to slope away from the pit to avoid filling the pit with water in times of rain.

8.4.1.4.3 Typical Equipment Containment Solutions

Figure 8.2 illustrates one method of pit construction that allows the equipment to be installed partially below ground. The sump pump can be manually operated during periods of heavy rain or automatically operated. If automatic operation is preferred, special precautions must be included to insure that oil is not pumped from the pits. This can be accomplished with either an oil-sensing probe or by having all major equipment provided with oil-limit switches (an option available from equipment suppliers). These limit switches are located just below the *minimum* top oil line in the equipment and will open when the oil level drops below this point.

A typical above-grade pit and/or berm, as shown in Figure 8.3, has maintenance disadvantages but can be constructed relatively easily after the equipment is in place at new and existing electrical facilities. These pits may be emptied manually by gate valves or pumps depending on the facility terrain and layout, or automatically implemented by the use of equipment oil limit switches and dc-operated valves or sump pumps.

Another method of pit construction is shown in Figure 8.4. The figure shows all-concrete containment pits installed around transformers. The sump and the control panel for the oil pump (located inside the sump) are visible and are located outside the containments. Underground piping provides the connection between the two adjacent containments and the sump. The containments are filled with fire-quenching stones.

8.4.2 Discharge Control Systems [IEEE 980-1994 (R2001)]

An adequate and effective station drainage system is an essential part of any oil-containment design. Drains, swales, culverts, catch basins, etc., provide measures to ensure that water is diverted away from the substation. In addition, the liquid accumulated in the collecting pits or sumps of various electrical equipment, or in the retention pit has to be discharged. This liquid consists mainly of water (rainwater, melted snow or ice, water spray system discharges, etc.). Oil will be present only in case of an equipment discharge. It is general practice to provide containment systems that discharge the accumulated water into the drainage system of the substation or outside the station perimeter with a discharge control system.

These systems, described below, provide methods to release the accumulated water from the containment system while blocking the flow of discharged oil for later cleanup. Any collected water has to be

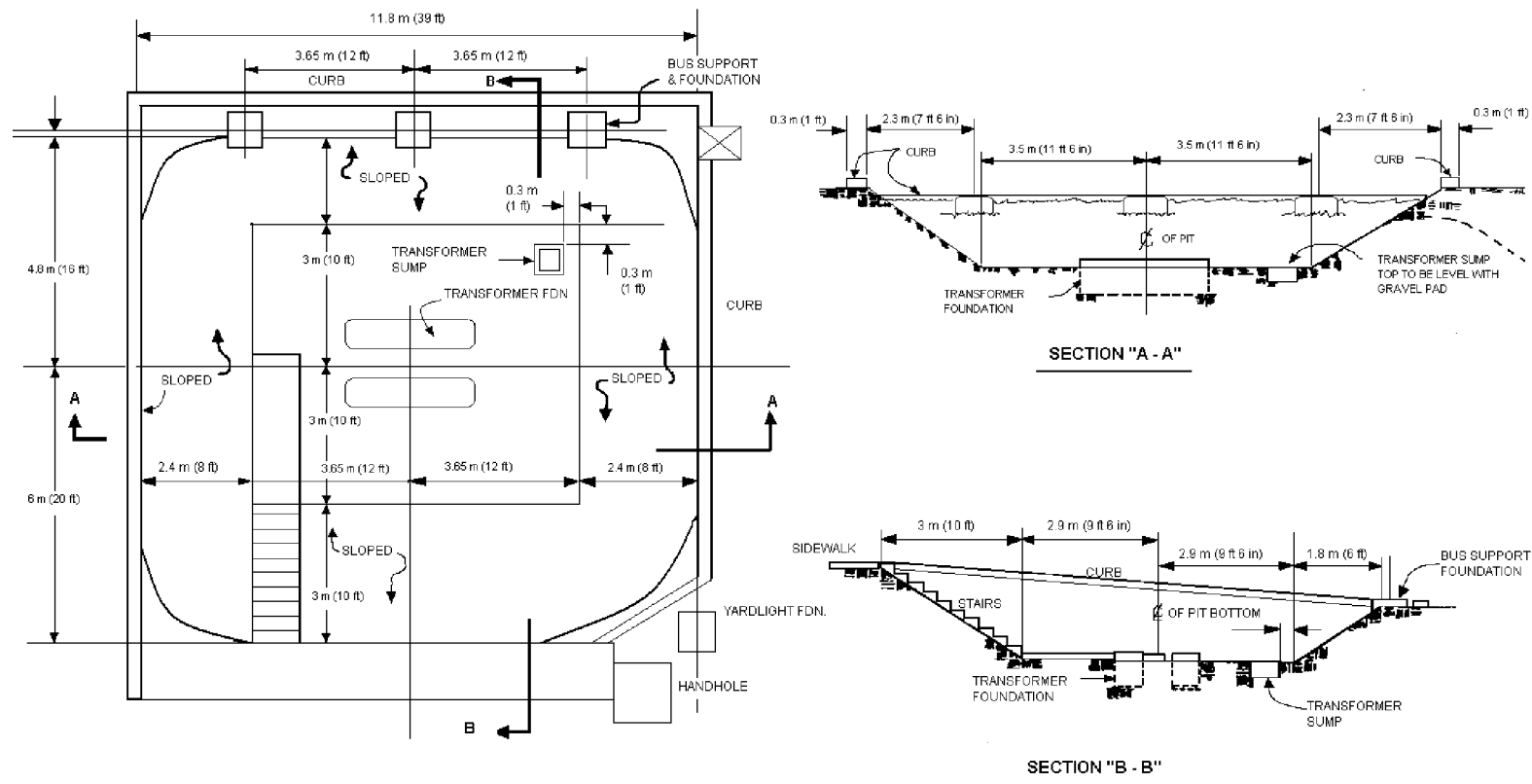


FIGURE 8.2 Typical below-grade containment pit.

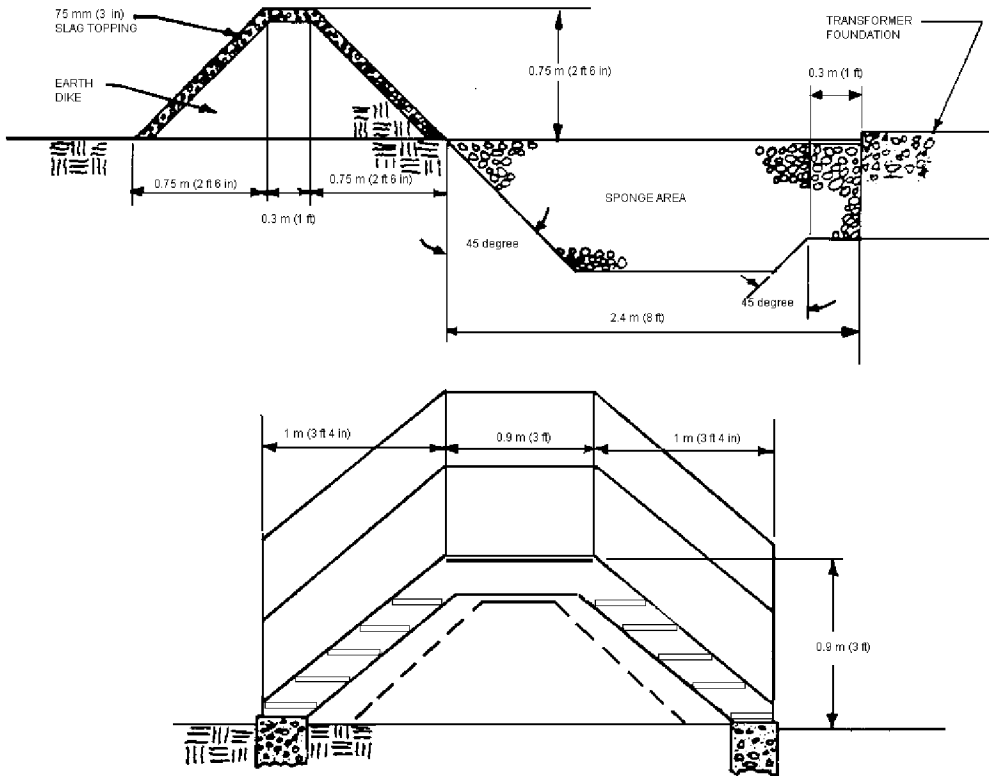


FIGURE 8.3 Typical above-grade berm/pit.

released as soon as possible so that the entire capacity of the containment system is available for oil containment in the event of a spill. Where the ambient temperatures are high enough, evaporation may eliminate much of the accumulated water. However, the system still should be designed to handle the worst-case event.

8.4.2.1 Oil-Water Separator Systems [IEEE 980-1994 (R2001)]

Oil-water separator systems rely on the difference in specific gravity between oil and water. Because of that difference, the oil will naturally float on top of the water, allowing the water to act as a barrier and block the discharge of the oil.

Oil-water separator systems require the presence of water to operate effectively, and will allow water to continue flowing even when oil is present. The presence of emulsified oil in the water may, under some turbulent conditions, allow small quantities of oil to pass through an oil-water separator system.

Figure 8.5 [IEEE 980-1994 (R2001)] illustrates the detail of an oil-water gravity separator that is designed to allow water to discharge from a collecting or retention pit, while at the same time retaining the discharged oil.

Figure 8.6 [IEEE 980-1994 (R2001)] illustrates another type of oil-water separator. This separator consists of a concrete enclosure, located inside a collecting or retention pit and connected to it through an opening located at the bottom of the pit. The enclosure is also connected to the drainage system of the substation. The elevation of the top of the concrete weir in the enclosure is selected to be slightly above the maximum elevation of discharged oil in the pit. In this way, the level of liquid in the pit will be under a layer of fire-quenching stones where a stone-filled pit is used. During heavy accumulation of water, the liquid will flow over the top of the weir into the drainage system of the station. A valve is incorporated in the weir. This normally closed, manually operated valve allows for a controlled discharge of water from the pit when the level of liquid in the pit and enclosure is below the top of the weir.

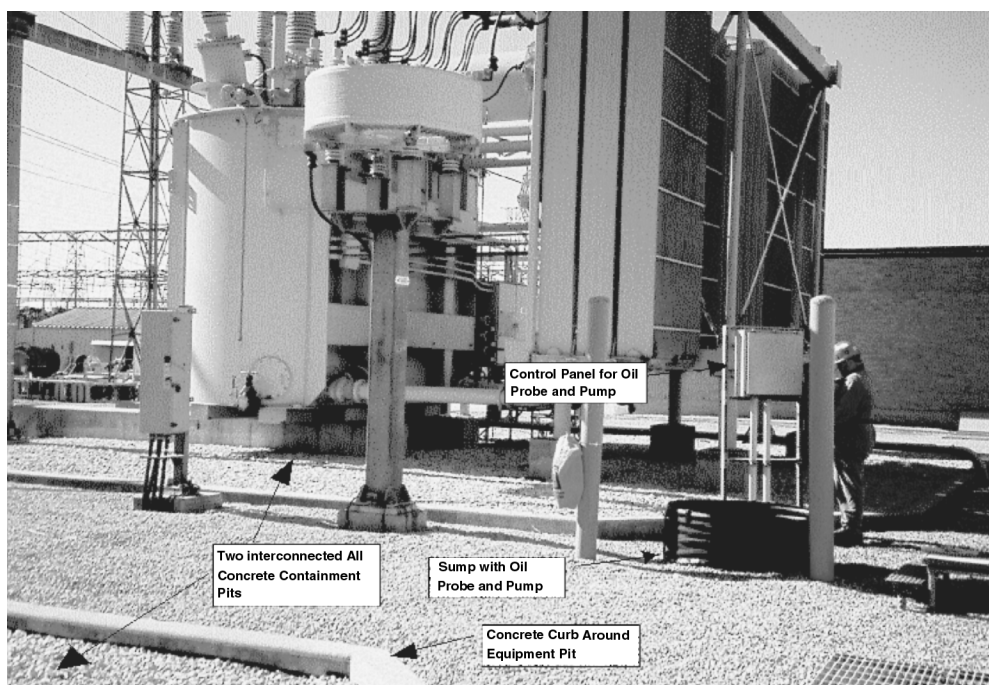


FIGURE 8.4 All-concrete containment pits.

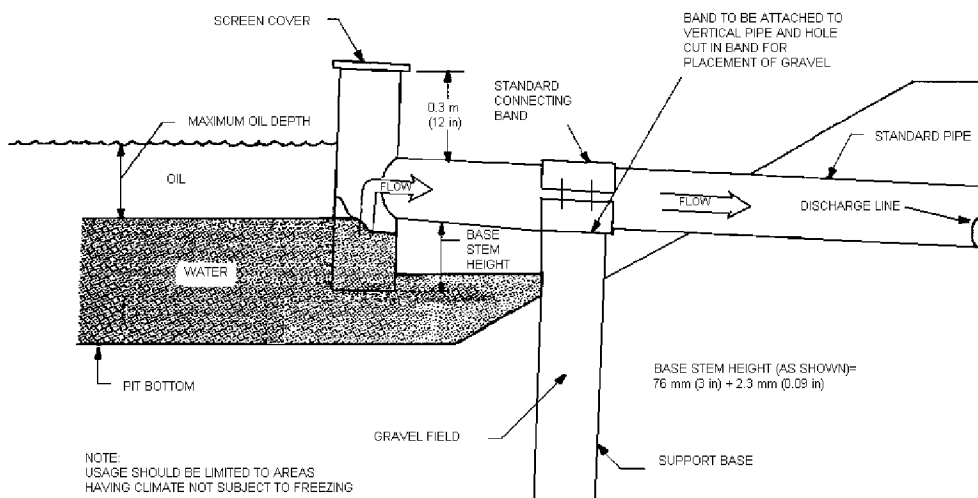


FIGURE 8.5 Oil-water gravity separator.

Figure 8.7 [IEEE 980-1994 (R2001)] provides typical detail of an oil-trap type oil-water separator. In this system, the oil will remain on top of the water and not develop the head pressure necessary to reach the bottom of the inner vertical pipe. In order for this system to function properly, the water level in the manhole portion of the oil trap must be maintained at an elevation no lower than 0.6 m (2 ft) below the inlet elevation. This will ensure that an adequate amount of water is available to develop the necessary hydraulic head within the inner (smaller) vertical pipe, thereby preventing any discharged oil from leaving the site. It is important to note that the inner vertical pipe should be extended downward past the

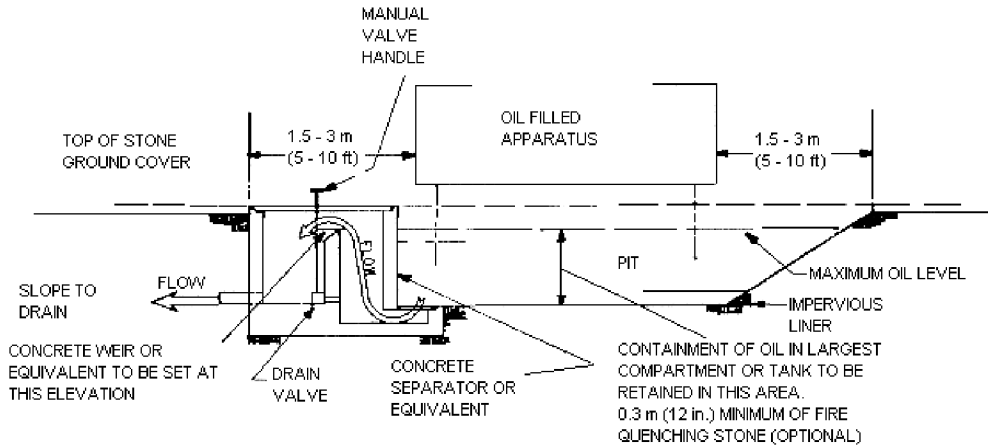


FIGURE 8.6 Equipment containment with oil-water separator.

calculated water-oil interface elevation sufficiently to ensure that oil cannot discharge upward through the inner pipe. Likewise, the inner pipe must extend higher than the calculated oil level elevation in the manhole to ensure that oil does not drain downward into the inner pipe through the vented plug. The reason for venting the top plug is to maintain atmospheric pressure within the vertical pipe, thereby preventing any possible siphon effect.

8.4.2.2 Flow Blocking Systems [IEEE 980-1994 (R2001)]

Described below are two oil flow blocking systems that do not require the presence of water to operate effectively. These systems detect the presence of oil and block all flow (both water and oil) through the discharge system. The best of these systems have been shown to be the most sensitive in detecting and blocking the flow of oil. However, they are generally of a more complex design and may require greater maintenance to ensure continued effectiveness.

Figure 8.8 illustrates an oil stop valve installed inside a manhole. The valve has only one moving part: a ballasted float set at a specific gravity between that of oil and water. When oil reaches the manhole, the float in the valve loses buoyancy and sinks as the oil level increases until it sits on the discharge opening of the valve and blocks any further discharge. When the oil level in the manhole decreases, the float will rise automatically and allow discharge of water from the manhole. Some of the oil stop valves have a weep hole in the bottom of the valve that allows the ballasted float to be released after the oil is removed. This can cause oil to discharge if the level of the oil is above the invert of the discharge pipe.

Figure 8.9 illustrates a discharge control system consisting of an oil-detecting device and a pump installed in a sump connected to the collecting or retention pits of the oil-containment system. The oil-detecting device may use different methods of oil sensing (e.g., capacitance probes, turbidimeters, and fluorescence meters). The capacitance probe shown detects the presence of oil on the surface of the water, based on the significant capacitance difference of these two liquids and, in combination with a logic of liquid level switches, stops the sump pump when the water-oil separation layer reaches a preset height in the sump. Transformer low oil level or gas protection can be added into the control diagram of the pump in order to increase the reliability of the system during major spills.

Some containment systems consist of collecting pits connected to a retention pit or tank that have no link to the drainage system of the substation. Discharge of the liquid accumulated in these systems requires the use of permanently installed or portable pumps. However, should these probes become contaminated, they may cease to function properly. Operating personnel manually activate these pumps. This system requires periodic inspection to determine the level of water accumulation. Before pumping any accumulated liquid, an inspection is required to assess whether the liquid to be pumped out is contaminated.

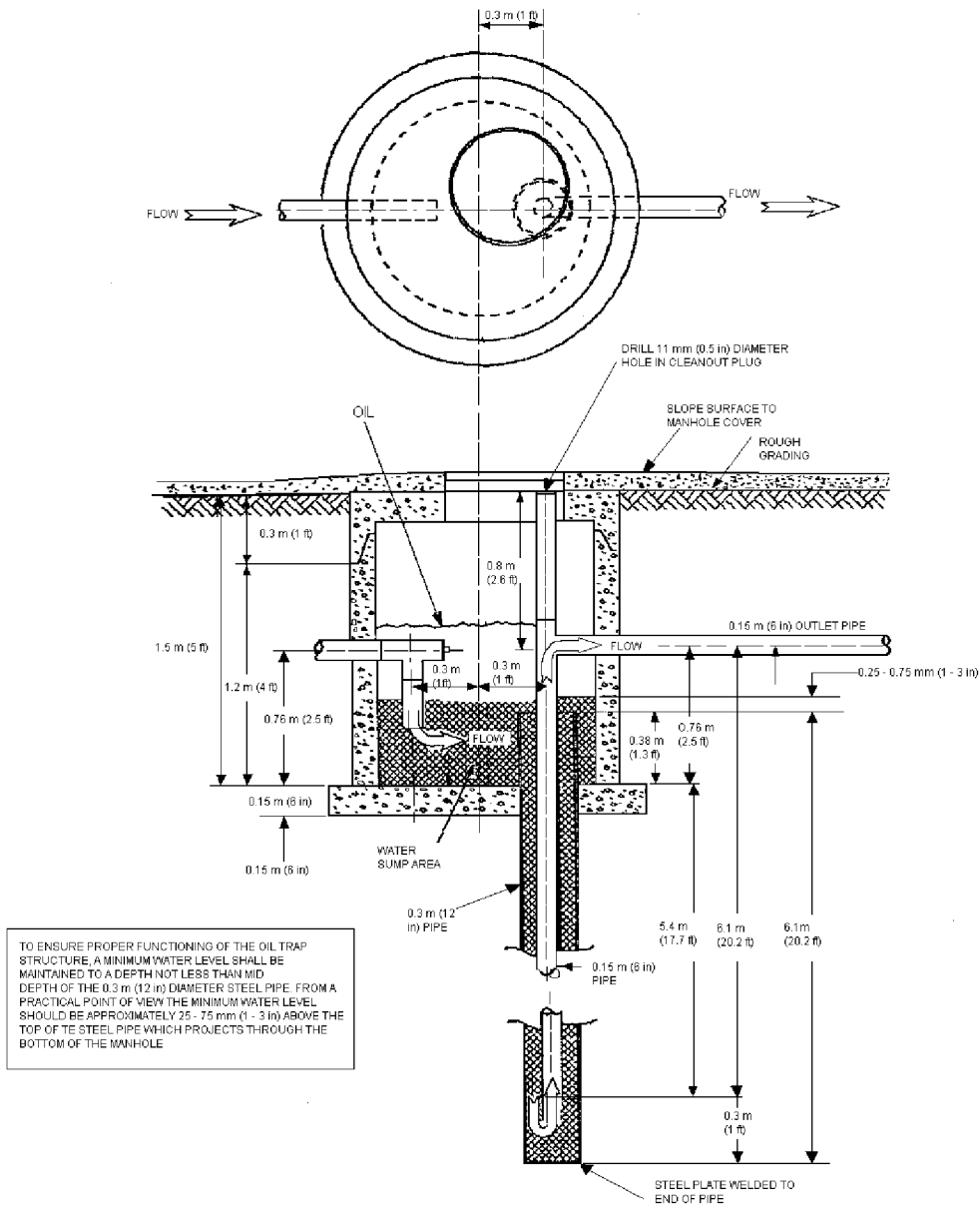


FIGURE 8.7 Oil-trap type oil-water separator.

8.4.3 Warning Alarms and Monitoring [IEEE 980-1994 (R2001)]

In the event of an oil spill, it is imperative that cleanup operations and procedures be initiated as soon as possible to prevent the discharge of any oil, or to reduce the amount of oil reaching navigable waters. Hence, it may be desirable to install an early detection system for alerting responsible personnel of an oil spill. Some governmental regulations may require that the point of discharge (for accumulated water) from a substation be monitored and/or licensed.

The most effective alarms are the ones activated by the presence of oil in the containment system. A low oil-level indicator within the oil-filled equipment can be used; however, it may not activate until 3–6% of the transformer oil has already discharged. In cases where time is critical, it may be worthwhile

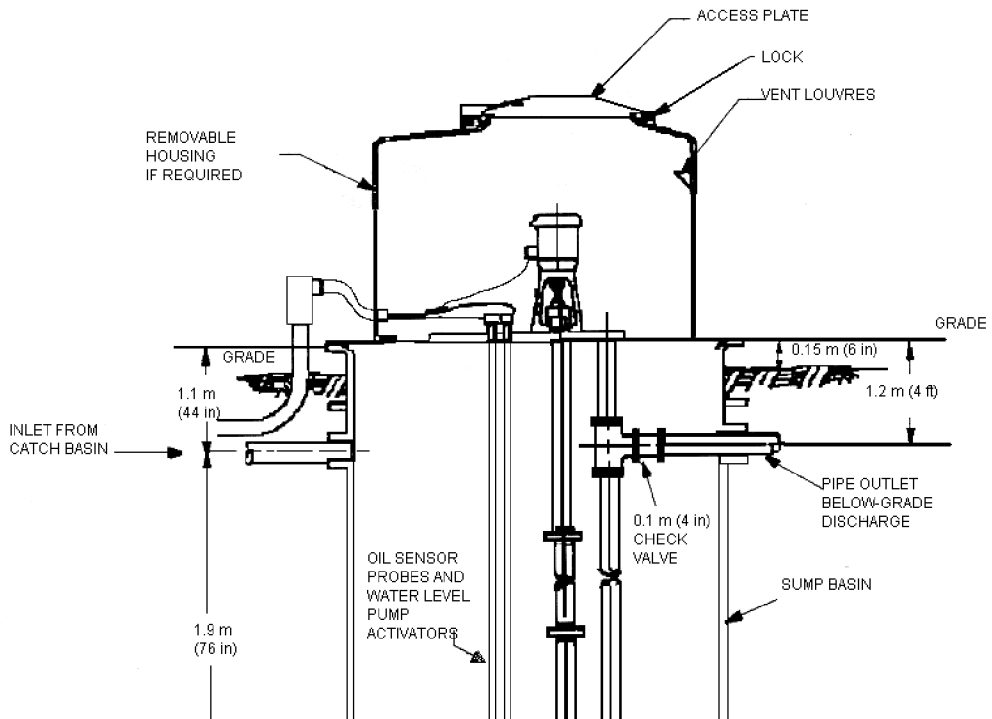


FIGURE 8.8 Oil stop valve installed in manhole.

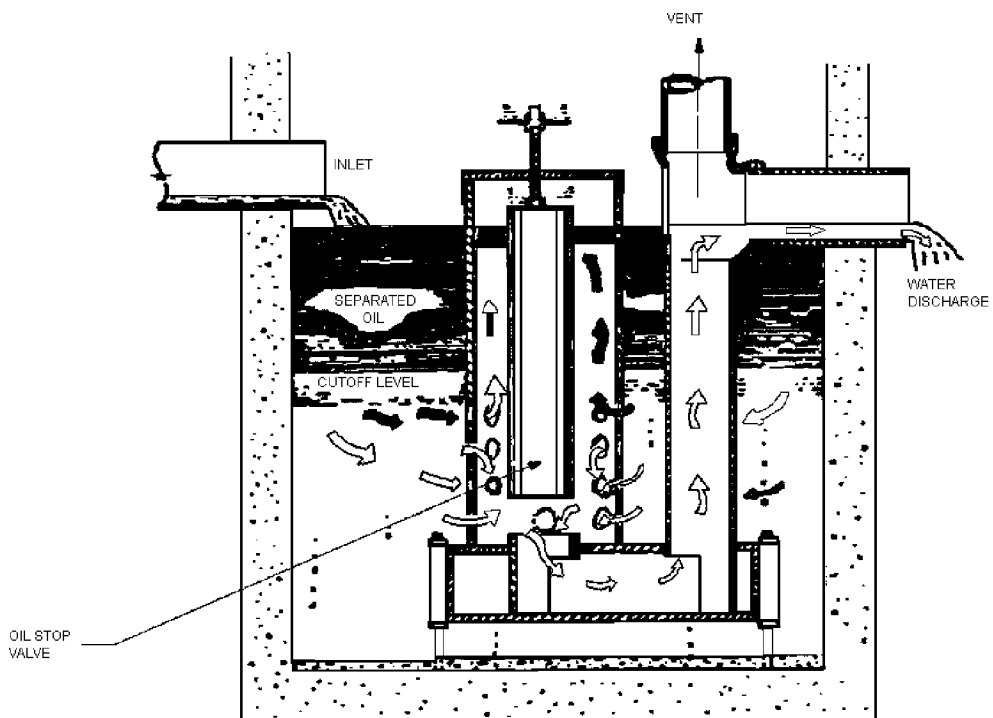


FIGURE 8.9 Sump pump water discharge (with oil-sensing probe).

to also consider a faster operating alarm such as one linked to the transformer sudden gas pressure relay. Interlocks have to be considered as a backup to automatic pump or valve controls.

Alarms are transmitted via supervisory equipment or a remote alarm system to identify the specific problem. The appropriate personnel are then informed so that they can determine if a spill has occurred and implement the SPCC contingency plan.

References

Design Guide for Oil Spill Prevention and Control at Substations, U.S. Department of Agriculture, Rural Electrification Administration Bulletin 65-3, January, 1981.

IEEE Guide for Containment and Control of Oil Spills in Substations, IEEE Std. 980-1994 (R2001).